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(54) Abstract Title

A split mechanical face seal

(57) A split mechanical face seal assembly (20) wherein stator (26) and rotor (24) face rings and their respective surrounding collar (23) and gland (25) are all split substantially diametrically and are partially factory preassembled to facilitate shipping, handling and subsequent assembly onto a machine at the job site. The split rotor face ring (24) and the split supportive collar (23) have the co-operating parts thereof subassembled into two subassemblies which define opposed halves for permitting them to be assembled on diametrically opposite sides of a shaft (12), with each subassembly having the rotor face ring segment (24) carried on the support collar segment (23), and an elastomeric seal ring (51) which co-operates between the segments being preassembled therebetween. The stator face ring (26) and its supporting gland ring (25) also have the respective split segments thereof, and the other co-operating components such as seal rings (86), preassembled at the factory to define a pair of subassemblies.

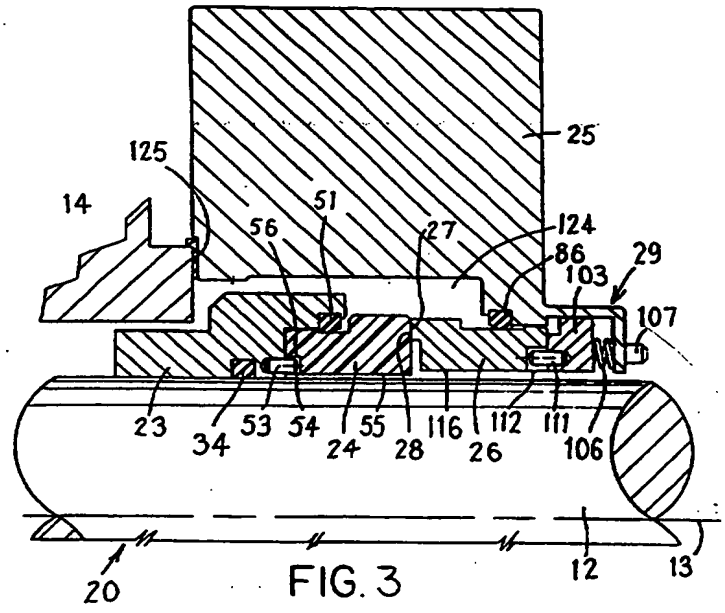

FIG. 3

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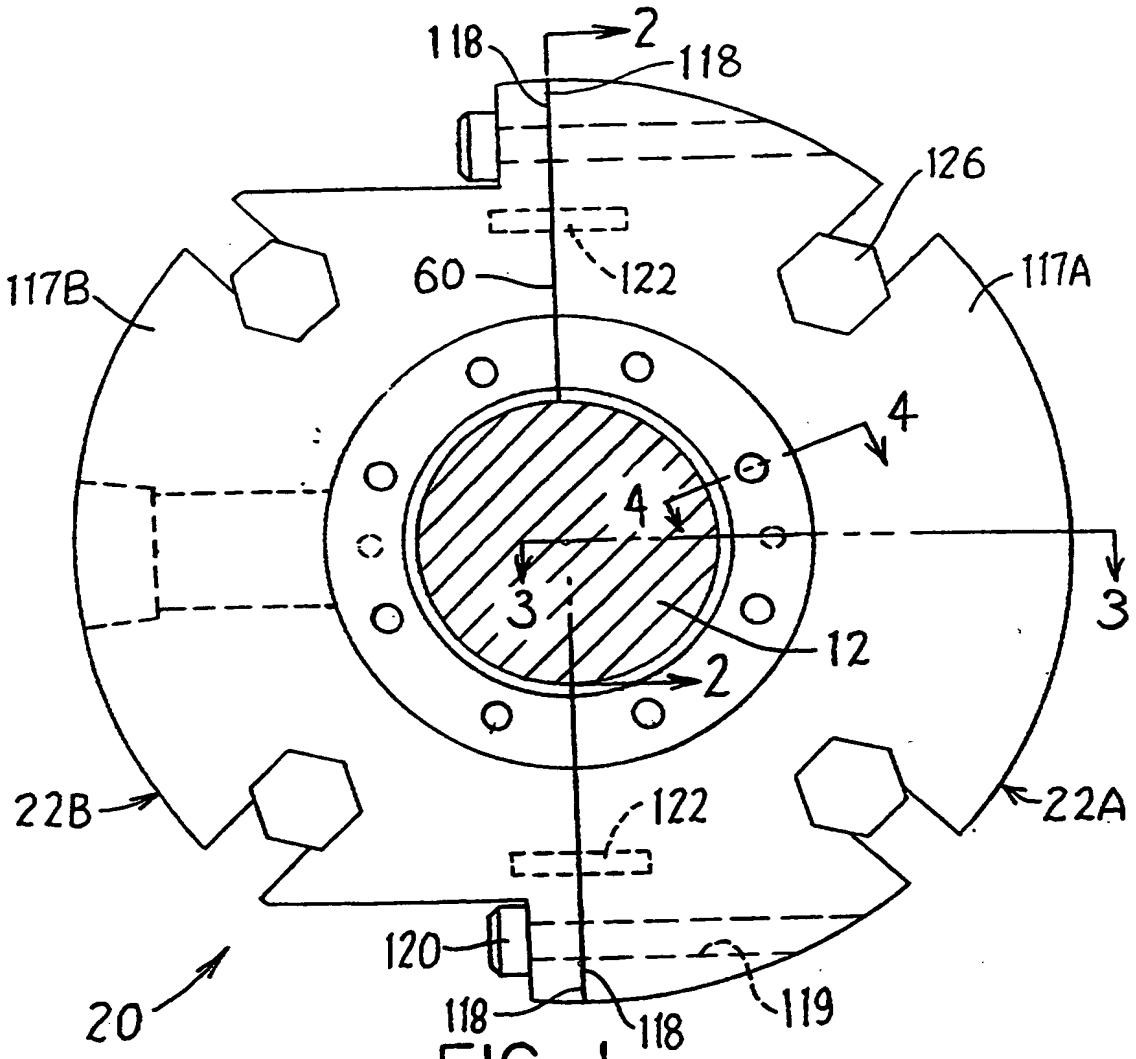

FIG. 1

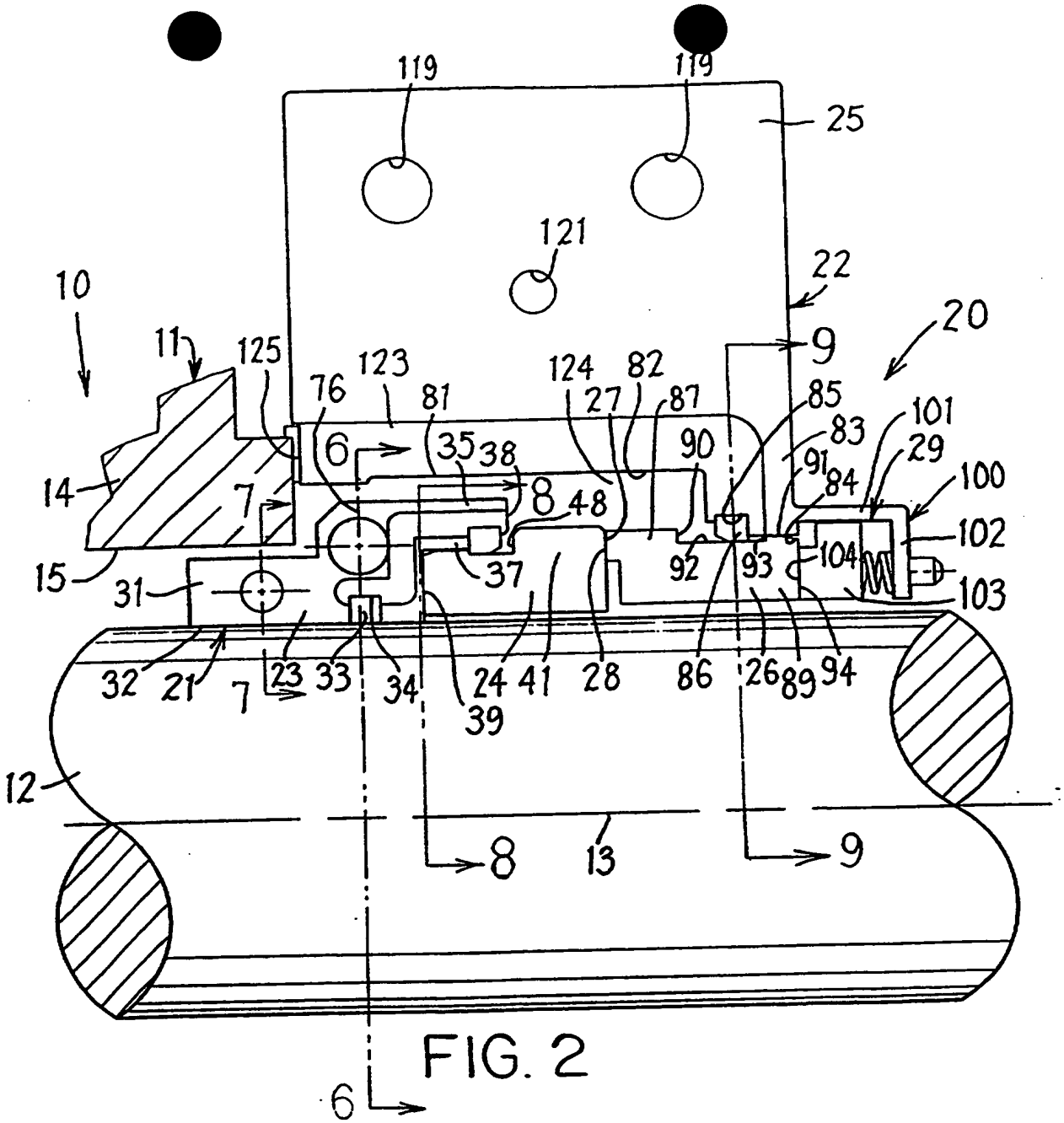

FIG. 2

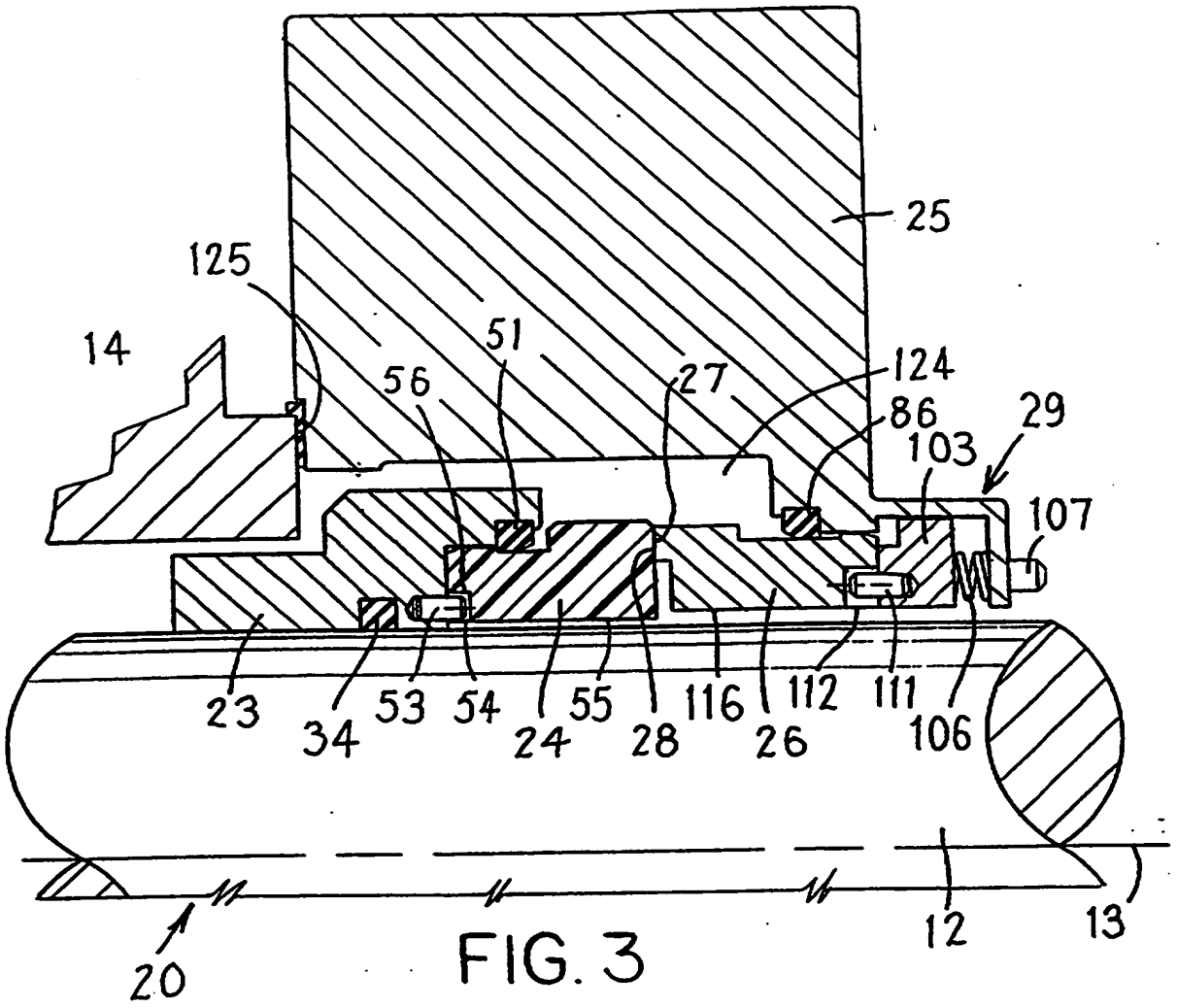

FIG. 3

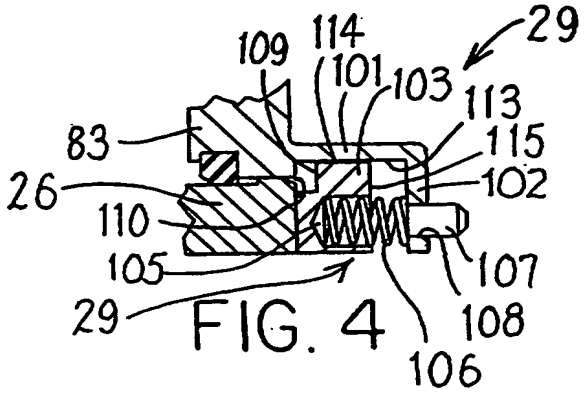

FIG. 4

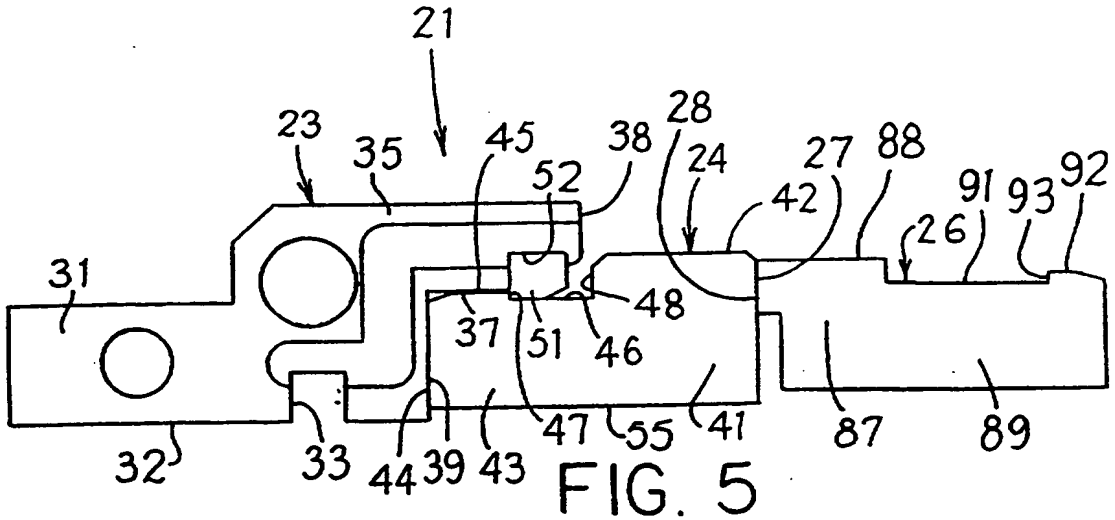

FIG. 5

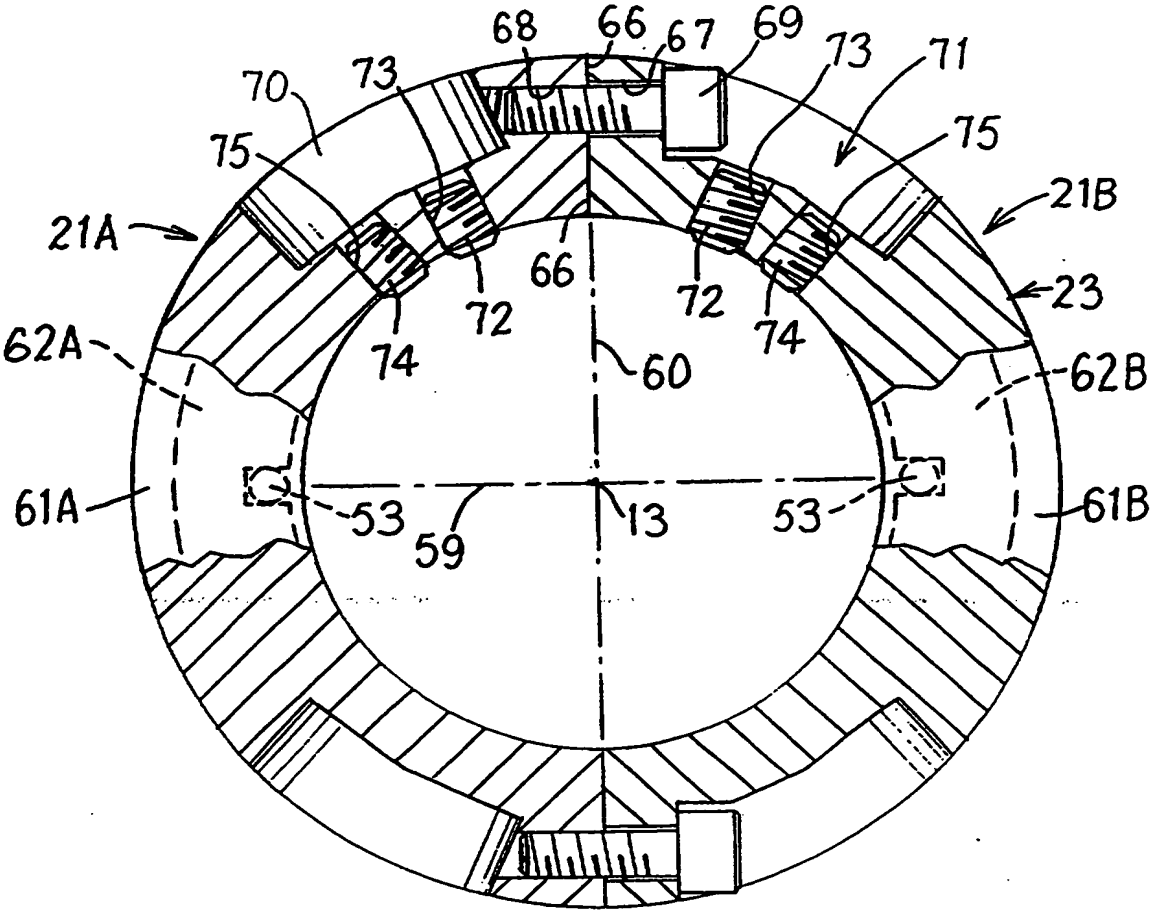

FIG. 6

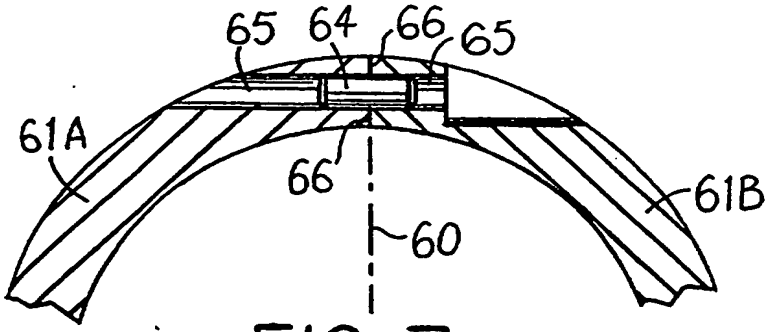

FIG. 7

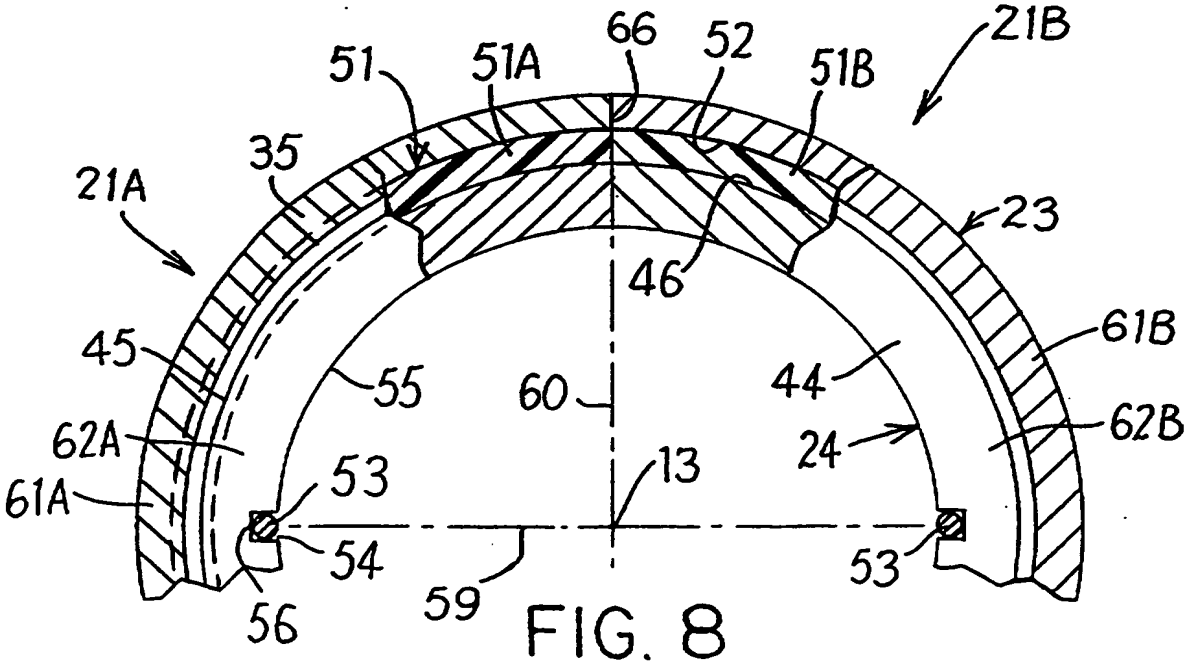

FIG. 8

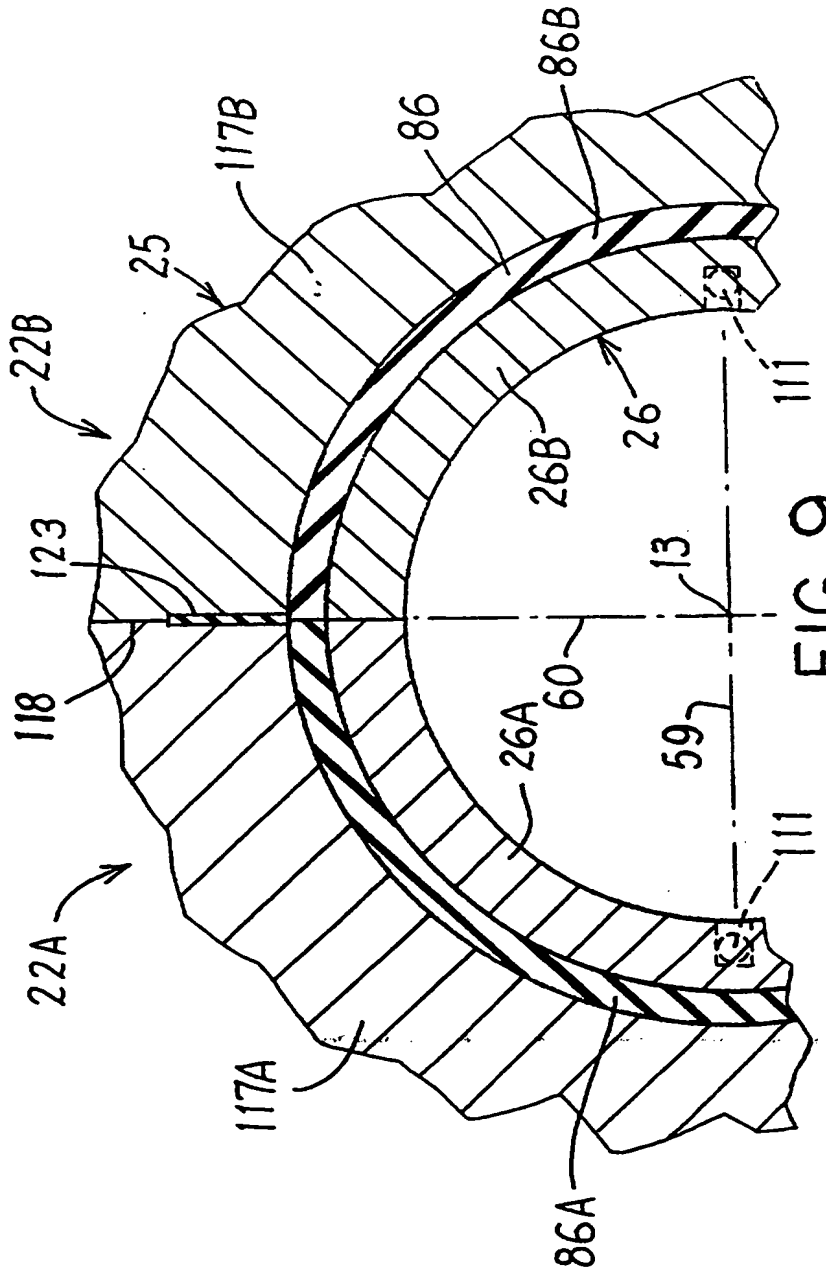

FIG. 9

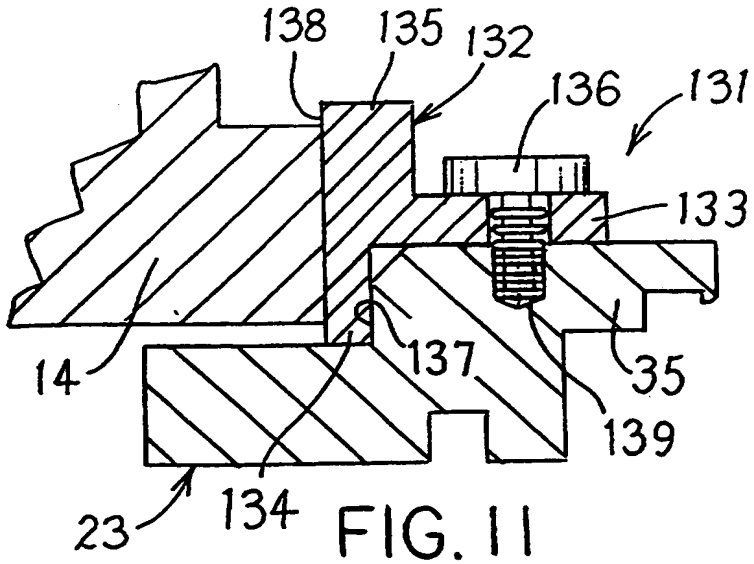

FIG. 11

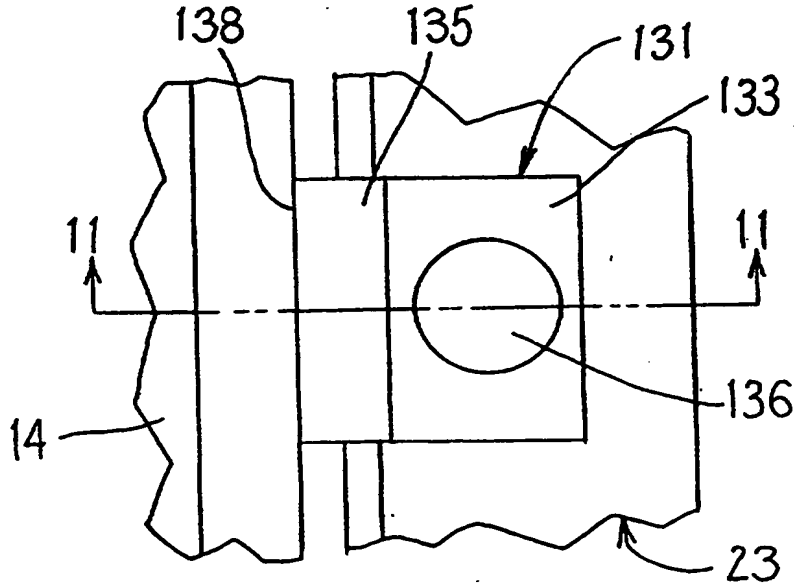

FIG. 10

SPLIT MECHANICAL FACE SEAL

This invention relates to an improved split mechanical face seal assembly for pumps and the like.

Mechanical face seal assemblies are used on machines including pumps and the like to create a sealed relationship between a rotating shaft and a surrounding housing. Since installation or replacement of mechanical seal assemblies employing one-piece ring members is time consuming and complex, split seal assemblies have been developed to facilitate installation and repair.

The split face seal assemblies are typically split generally diametrically along the axis of the assembly so that the face rings as well as the support rings therefor are all diametrically split whereby the seal assembly components can be mounted on or removed relative to the shaft without requiring excessive disassembly of the overall machine. While split mechanical seal assemblies are recognized to possess desirable advantages, nevertheless the construction of split seal assemblies continues to present a significant problem with respect to manufacture, assembly and performance thereof.

Most known split mechanical face seal assemblies have the stator and rotor face rings split diametrically, and also employ a support collar and a gland member which respectively cooperate with the rotor and stator face rings and which are also diametrically split. All other associated members such as elastomeric seal rings and the like are also split to permit their positioning around the shaft. This construction and the multiple parts thereof hence creates a significant assembly problem since the numerous parts must be field assembled onto the machine (for example a pump), and the parts must cooperate with the precision and fit necessary to provide the desired sealing performance. In particular, manipulating and assembling this large number of parts at

an on-site location and at the same time obtaining or maintaining proper fit and engagement between the parts is complex and time consuming. Further, many of the split seals currently commercially available have exhibited unacceptable leakage levels.

In addition, because of the difficulties in obtaining proper flatness and opposed flat engagement between opposed contacting seal faces defined on diametrically-split rotor and stator face rings, some known constructions have supported these rings and specifically the rotor on resilient support rings in an attempt to compensate for irregularities and distortion. Further, in some known constructions the pressure of the working fluid (i.e., the pump fluid) in the stuffing box acts against and urges the rotor face ring more tightly against its supporting collar, and this tends to further increase distortion and the resulting overall performance problems associated with the seal assembly.

It is an object of preferred embodiments of this invention to provide an improved split mechanical face seal assembly which improves on and overcomes many of the disadvantages which are present in many of the current commercially available split mechanical seals.

More specifically, the invention relates to an improved split mechanical face seal assembly wherein the stator and rotor face rings and their respective surrounding collar and gland are all split substantially diametrically and are partially factory preassembled to define a reduced number of preassembled subassemblies so as to facilitate shipping, handling and subsequent assembly onto a machine at the job site.

In a preferred embodiment of the invention, the split rotor face ring and split supportive collar have cooperating parts thereof subassembled into two subassemblies which define opposed halves for permitting them to be assembled on diametrically opposite sides of a shaft, with each subassembly having the rotor face ring

segmen[redacted]arried on the support colla[redacted]egment, and an elastomeric seal ring which cooperates between the segments being preassembled therebetween. The stator face ring and its supporting gland ring also have the respective split segments thereof, and the other cooperating components such as seal rings, preassembled at the factory to define a pair of subassemblies.

In an improved split mechanical seal assembly of this invention, particularly a preferred embodiment, the split rotor has a rear surface directly and substantially rigidly seated against an opposed surface defined on the split collar, and the rotor and stator face rings have diametrical relationships such that, when externally acted on by the pressurized pump or working fluid, the pressurized fluid exerts an unbalanced force against the rotor which acts in a direction away from the seating surface to thus minimize and in fact possibly reduce the spring-induced seating contact pressure between the rotor face ring and the collar.

Figure 1 is an end view of a split mechanical face seal assembly according to the invention.

Figure 2 is an enlarged fragmentary sectional view taken along line 2-2 in Figure 1.

Figure 3 is an enlarged fragmentary sectional view taken along line 3-3 in Figure 1.

Figure 4 is an enlarged fragmentary sectional view taken along line 4-4 in Figure 1.

Figure 5 is an enlarged fragmentary view of the opposed face rings shown in Figure 2.

Figure 6 is an enlarged fragmentary sectional view taken along line 6-6 in Figure 2.

Figure 7 is an enlarged fragmentary sectional view taken along line 7-7 in Figure 2.

Figure 8 is an enlarged fragmentary sectional view taken along line 8-8 in Figure 2.

Figure 9 is an enlarged fragmentary sectional view taken along line 9-9 in Figure 2.

Figure 10 is a fragmentary top view illustrating a clip on the rotor assembly to facilitate positioning during installation.

Figure 11 is a fragmentary sectional view taken along line 11-11 in Figure 10.

Figures 1-3 illustrate parts of a fluid handling device 10, such as a pump, having a housing 11 defining therein a fluid chamber (not shown) and provided with a shaft 12 which rotates about its axis 13, which shaft in a typical pump has a pumping impeller (not shown) secured thereto. The shaft 12 projects outwardly through a sleeve like housing part 14 which defines therein an annular chamber 15, commonly referred to as a stuffing box.

A mechanical face seal assembly 20 surrounds the shaft and cooperates with the stuffing box 14 to seal the interior of the fluid handling device and prevent the pump or process fluid from escaping to the surrounding environment.

The improved mechanical face seal assembly 20 of the present invention is of an axially split construction, described hereinafter, to facilitate mounting or demounting of the assembly relative to the shaft. The seal assembly includes a rotor assembly 21 which surrounds the shaft and is nonrotatably coupled thereto. The rotor assembly cooperates with a stator assembly 22 which also substantially concentrically surrounds the shaft but is mounted on and hence is nonrotatably carried by the housing 11. The rotor and stator assemblies 21 and 22 cooperate to define a face seal which effectively seals the outer end of the stuffing box 14.

In the seal assembly 20, the rotor assembly 21 includes a sleevelike collar 23 which concentrically surrounds and is nonrotatably and sealingly secured to

the shaft 12, and this collar in turn concentrically mounts thereon a seal or face ring 24, often referred to as the rotor. The stator assembly 22 includes a sleevelike support member 25, commonly referred to as the gland, the later being disposed in surrounding relationship to the shaft and being fixably secured to the housing 11. The gland 25 in turn mounts thereon a seal or face ring 26, commonly referred to as a stator. The face rings 24 and 26 are disposed in substantially concentric and surrounding relationship to the shaft and are positioned axially adjacent in opposed relationship, and defined flat annular seal faces 27 and 28 thereon which are positioned substantially within planes which extend in perpendicular relationship with respect to the axes of the respective rings. The stator assembly 22 also has a spring unit 29 associated therewith and coating with the outer end of the face ring 26 so as to urge the later axially toward the face ring 24, whereby the opposed seal faces 27 and 28 are maintained in abutting and relatively rotatable sliding contact with one another to define an annular contact seal between regions disposed adjacent the radially inner and outer peripheral edges of this annular contact seal.

The constructional and operational features of seal assembly 20, as summarized above, are well known.

Considering the seal assembly 20 in greater detail, and referring initially to the rotor assembly 21, the sleevelike collar 22 includes a rear annular sleeve part 31 having an inner annular peripheral wall 32 which is sized to closely fit the outer diameter of the shaft 12. This inner wall 32 has an annular groove 33 undercut therein and the latter accommodates therein an annular elastomeric seal ring 34 for creating a sealed engagement with the periphery of the shaft 12. The collar 23 also has a front sleeve part 35 which is integral with the rear sleeve part 31 and which defines therein an enlarged annular bore or chamber 37 which opens axially inwardly

from the front end face 38 of the collar. The inner annular wall 37 of the bore projects axially inwardly only over a portion of the overall length of the collar so as to terminate at an annular flat rear or bottom wall 39 which extends radially inwardly for intersection with the inner annular wall 33 and is disposed within a plane which substantially particularly intersects the longitudinal axis of the collar.

The face ring 24 is typically constructed of silicon carbide or ceramics and is sealingly and nonrotatably carried on the collar 23, and includes a nose part 41 defined by an outer peripheral annular wall 42, with nose part 41 terminating in a generally radially projecting rear wall 48 which is typically spaced forwardly from the collar end wall 38. The face ring 24 also has an annular rear part 43 which is integral with and projects rearwardly from the nose part 41, and which terminates in a flat annular rear wall 44 disposed in a plane which perpendicularly intersects the axis of the face ring and is maintained in seating contact with the opposed collar wall 39. The rear sleeve part 43 of the face ring 24 has a rear annular outer peripheral wall 45 which projects axially forwardly from the rear wall 44 through a fraction, approximately one-half in the illustrating embodiment, of the distance towards the rear wall 48 of the nose part. The rear sleeve part 43 also has, disposed axially between the nose part 41 and the rear peripheral wall 45, an intermediate outer annular peripheral wall 46 which is of slightly smaller diameter than the rear peripheral wall 45, with the two walls being joined by an annular shoulder 47 which projects radially between the walls 46 and, and which faces axially forwardly toward the rear wall 48.

As illustrated in Figures 2 and 3, the rear sleeve part 43 of face ring 24 is substantially concentrically disposed within the front sleeve part 35 of collar 23 and the later mounts thereon an annular elastomeric seal ring

51 which is secured within an undercut groove 52 which opens radially outwardly from the inner annular wall 37. The groove 52 and the seal ring 51 carried therein is positioned closely adjacent the free end of the collar sleeve part 35. In addition, the elastomeric seal ring 51 projects radially inwardly to create an annular sealed engagement with the exterior of the face ring 24, with the disposition of the seal ring being such that it engages the intermediate outer peripheral wall 46 just forwardly or outwardly of the shoulder or step 47 when the face ring is seated against the rear collar wall 39, whereby the seal ring 51 cooperates with the shoulder or step 47 to thus axially retain the face ring 24 in a position wherein it is seated within the collar 23, substantially as illustrated by Figures 2 and 3.

To further assist in connecting and nonrotatably coupling the collar 23 and face ring 24 together, the collar 23 has at least two drive pins 53 (Figures 3 and 6) secured thereto, for example by being press fit into bores which projects axially inwardly from the rear surface 39 in close proximity to the inner diameter 32. The drive pin 53 projects axially outwardly beyond the rear surface 39 and is adapted to project into a small notch or groove 54 formed adjacent the rear inner corner of the rear sleeve part 43 of face ring 24. The notch 54 opens radially outwardly from the inner annular cylindrical wall 55 of the face ring 24, the diameter of which is normally slightly greater than the diameter of the wall 32 of the collar. The notch 54 projects radially from the inner wall 55 through a small distance so as to terminate at a radially outer wall 56 which is normally positioned closely adjacent the outer side of pin 53 when the mechanical seal assembly is mounted on the shaft. The circumferential width of the notch 54 also closely conforms to and only slightly exceeds the diameter of pin 53 so that the pin 53 acts as a driving

pin for [redacted] rotatably coupling the colla[redacted]23 and face ring 24 together.

The rotor assembly 21 is diametrically split generally along the plane 60 (Figures 1 and 6) into two substantially identical and substantially semicircular subassemblies which are designated 21A and 21B. In this respect, the diametrical split results in the sleevelike collar 23 being split into substantially semicylindrical collar segments 61A and 61B, the rotor or face ring 24 being split into two substantially identical and semicircular rotor segments 62A and 62B, and the elastomeric seal ring 51 being split into two substantially identical semi-cylindrical seal ring segments.

Each of the rotor subassemblies 21A and 21B can be initially factory preassembled to facilitate shipping, handling and subsequent assembly at the job site. Considering the rotor subassembly 21A as an example, the rotor segment 62A is axially inserted into the respective collar segment 61A in such fashion that the rotor affects compression of the respective segment of the elastic seal ring 51 carried by the collar segment 61A. The rotor segment 62B is axially inserted into the collar segment until the opposed walls 39 and 44 abut, in which position the elastic seal ring segment 51 expands to engage the annular wall 46 directly forwardly of the step or shoulder 47 to axially hold the seal ring segment 51 within the collar. At the same time, during insertion of the face ring segment 62A into the collar segment 61A, the drive pin 53 of the collar segment projects into the notch 54 which, due to the close positional relationship between the pin 53 and the adjacent radially outer wall 56 of the notch 54, causes the pin 53 to effectively engage the outer notch wall 56 due to the resilient urging of the elastic seal ring 51. The drive pin 53 cooperating with the radially outer wall of the notch, and the seal ring 52 cooperating with the shoulder 47,

thus f[redacted]tion to securely retain the [redacted]lar and face ring segments 61A , 62A together to create a preassembled or unitized rotor subassembly 21A. Both rotor subassemblies 21A and 21B are preassembled in this matter.

To optimize the above relationship, the drive pin 53 and its cooperating notch 54 are disposed generally within a plane 61 which perpendicularly intersects the splitting plane 60 generally at the longitudinal central axis 31 of the rotor assembly so that the pin and notch are thus midway between the ends of the semicircular segments. While this disposition is preferred so as to optimize the use of a single drive pin per segment, it will be appreciated that each segment can be provided with two or more drive pins, and as such the location thereof can be varied.

To permit fixed securement of the rotor subassemblies segments 21A and 21B to the shaft 12 in surrounding relationship therewith, the opposite ends of the collar segments 61A and 61B are provided with openings 65 which extend perpendicularly from the flat end surfaces 66 of the collar segments, which end surfaces are defined generally by the splitting plane 60, with the openings 65 in the ends of the rotor segments being aligned when the opposed end surfaces 66 abut. An alignment pin 64 is fixed, as by a press fit within the opening 65 of one of the collar segments and projects outwardly therefrom for snug slidable engagement into the opposed opening 65 of the other collar segment. Such alignment pin 64 is provided at each end of one of the collar segments so that the pair of alignment pins hence slideably engage the openings in the other collar segment to permit the two collar segments to be properly aligned on opposite sides of the shaft, and then moved into full engagement with one another in concentric relationship to the shaft.

To thereafter secure the rotor subassemblies 21A and 21B together, the collar segment 61B has a smooth bore 67

which projects perpendicularly away from the flat end surface 66 at each end of the collar segment and the other collar segment 61A has a threaded bore 68 which opens away from the end surface 66 at each end of the collar segment. The threaded bores 68 respectively align with the nonthreaded bores 67, and a pair of threaded fasteners 69, such as cap screws, are inserted through the smooth bores 67 provided at opposite ends of the collar segment 61B and are threaded into the aligned threaded bores 68 provided in opposite ends of the collar segment 61A to thus securely fasten the collar segments together and thereby create a rigid annular structure. The collar segments may be provided with pockets 70 which open inwardly from the outer periphery thereof to facilitate access to the fasteners.

To in turn permit the rotor assembly 21 as assembled from the rotor subassemblies 21A and 21B to be nonrotatably secured to the shaft 12, the rotor assembly includes a shaft fastening arrangement 71 defined by a pair of threaded set screws 72 which individually cooperate with respective threaded bores 72 formed radially through the collar 23. The bores 72 extend radially so as to substantially intersect the shaft axis 13, and the bores are positioned closely adjacent but on circumferentially opposite sides of one of the cap screws 69 substantially as illustrated in Figure 6, whereby one said bore 73 is disposed adjacent the end of the collar segment 61A, and the other said bore 73 is disposed adjacent the opposed end of the other collar segment 61B. The pair of bores 73 and their close straddling relationship to the adjacent cap screw 69, and the radial orientation of the bores 73, is highly desirable since this results in the holding force between the set screws and shaft being oriented dominantly in a direction perpendicular to the longitudinal axis of the cap screw, and hence greatly minimizes the forces created from the

set screws 72 acting to effect separation of the collar segments.

In the illustrated arrangement, a further pair of set screws 74 are provided within threaded bores 75, the latter also extending radially intersecting relationship to the axis 13. The bores 75 circumferentially straddle the bores 73 and are positioned circumferentially closely adjacent the bores 73 so as to again minimize the set screw holding force which acts to effect separation between the collar segments. The dominate set screw force thus acts generally downwardly so that, as viewed in Figure 6, the bottom side of the shaft is securely engaged with the bottom peripheral surface of the collar.

The center line of the cap screws 69, as well as the center lines of the set screws 72 and 74, are all preferably disposed within a single transverse plane 76 (as shown in Fig. 6) which extends in perpendicular relationship to the axis 13, and which in the illustrated embodiment is disposed in close proximity to the transverse plane defined by the rear collar wall 39. This relationship and particularly the disposition of the cap screw and set screws within a common plane hence eliminates torsional or moment forces in the axial direction and hence significantly minimizes those moments and forces which tend to tortionally distort the collar and hence interfere with proper seating of the face ring 24 within the collar 23. This minimization of the distortion of the rotor 24 thus minimizes distortion of the seal face 27 and provides improved contact between the opposed flat seal faces 27 and 28.

It is preferred that the shaft fastening arrangement 71, as defined by the set screws 72 and 74, be provided on only one diametrical side of the collar 73, namely only at one opposed ends of the collar segments as illustrated in Figure 6, with the other opposed ends of the collar segments being cooperatively engaged solely through the alignment pin and the cap screw. Further,

while th[redacted]econd set of set screws 74 [redacted] desirable for providing redundancy with respect to securement of the collar to the shaft, it will be appreciated that the second set of set screws 74 is not required and can be eliminated if desired.

Considering now the construction of the stator assembly 22, and specifically the construction of the gland 25, it has a stepped bore 81 extending axially there through which is defined by an inner annular peripheral wall 82 which extends through a majority of the axial thickness of the gland member. The gland member, adjacent the outer wall thereof, has an annular wall part 83 which projects radially inwardly from the inner annular wall 82 and terminates at an inner annular wall 84 which extends axially outwardly. The wall 84 has an undercut annular groove 85 form therein, and an annular elastomeric seal ring 86 is captivated in the groove 5 and projects radially inwardly for sealing engagement with the stator 26.

The stator or face ring 26 is typically constructed of silicon carbide or carbon, and at its inner end has an annular nose part 87 defined by an outer annular peripheral wall 88. The nose part on the front and thereof defines the annular seal face 28 which cooperates with the opposed seal face 27 on the rotor 24.

The annular nose part 87 of the stator is integrally joined to a rear or outer sleeve part 89 which projects axially into the bore defined by the inner annular wall 84 on the gland. This rear sleeve part 89 projects axially rearwardly away from the annular rear wall 90 of the nose part and has an intermediate outer annular wall 92 which projects away from the rear nose wall 90 until reaching an annular shoulder 93 which projects radially outwardly and faces toward the rear nose wall 90. This annular shoulder 93 projects radially outwardly through a small extent, and then joins to a rear annular outer wall 91, which then continues to project axially outwardly or

rearwar[redacted] so as to terminate in a ge[redacted]ally transverse annular end wall 94.

The outer annular wall 91 is sized so as to be axially slideably engaged with the inner annular wall 84 of the gland, and the intermediate outer annular wall 92 is sized so as to be slideably but sealingly engaged with the elastomeric seal ring 86 normally in axially spaced relation from the shoulder 93.

The spring unit 29 cooperates with the outer end wall 94 of the stator to normally urge the latter into contact with the rotor. The gland 25 has an annular shroud 100 provided thereon for support and confinement of the spring unit 29. The shroud 100 includes an outer annular wall 101 which projects axially through a selected distance in concentric surrounding relationship to the axis 13, and at its outer end integrally joins to a ring like end wall 102 which projects radially inwardly to a diameter which is greater than the shaft diameter. The spring unit 29 includes a ring-shaped pusher member 103 having a transverse flat annular front or end face 104 which is normally maintained in abutting engagement with the end face 94 of the stator. The pusher member 103 also has a plurality of circumferentially spaced pockets or blind bores 105 formed therein and opening inwardly from the opposite end face 115 thereof. Each of these pockets 105 contains a small biasing member such as a coiled compression spring 106, and the latter projects axially toward and has an end thereof engaged with the inner surface of the shroud end wall 102. Each spring 106 also has a guide pin 107 fixed thereto and projected axially outwardly so as to be slideably engaged within a respective opening 108 formed through the shroud end wall 102. The engagement of the pins 107 within the openings 108, and the confinement of the springs 106 within the pockets 105 hence creates a nonrotatable connection between the gland shroud 100 and the pusher member 103.

The outer annular wall 114 of the pusher ring is sized so as to be axially slideably engaged with the inner annular wall 113 of the surrounding shroud wall 101. In addition, the pusher 103 has an annular face 109 formed adjacent the outer diameter thereof and facing axially inwardly in opposed relationship to an annular stop surface 110 defined on the gland wall 83 adjacent the inner annular wall 84 so as to limit the inward spring-urged position of the pusher member 103.

The pusher number 103 also has a pair of pins 111 secured thereto, preferably at diametrically opposed positions, which pins project axially outwardly from the front face of the pusher and project axially into opposed small grooves or notches 112 formed in the adjacent opposed end of the stator. The notches 112 open radially outwardly from the inner annular wall 116 of the stator, which wall 116 is sized so as to be somewhat greater than the shaft diameter. The size and position of the notch 112 and its cooperation with the pin 111 is substantially identical to the same size and positional relationships associated with the pin 53 and notch 54 associated with the rotor assembly, so that further description of the pin 111 and notch 112 is believed unnecessary.

The stator assembly 22 is also axially split along the diametrical plane 60 in the same manner as the rotor assembly, as described above. More specifically, the diametral and axial splitting of the stator assembly results in two substantially identical and substantially semi cylindrical gland segments 117 which each have, at opposite ends thereof, flat end surfaces 118 which substantially abuttingly engage the opposed end surface of the other gland segment when the two gland segments are coupled together.

The stator ring 26, the elastomeric seal ring 86 and the pusher ring 103 are also diametrically split into substantially identical semicircular segments so as to cooperatively mount on and permit preassembly with

respect[redacted] the respective semicircula[redacted]land member segments. In this regard, the split pusher ring segment is slideably retained in the respective gland segment due to the engagement of the spring glide pins 107 within the shroud openings 108 and the engagement of the pin 111 within the notch 112, whereby pin 111 radially retains the stator segment in engagement within the gland segment and specifically in at least partially compressed engagement with the segment of the elastomeric seal ring. The segment of the pusher ring is also axially restrained due to the stop face 109 abutting the stop surface 110 on the gland segment, and the stator segment is axially retained due to the axial interference created between the segment of the elastomeric seal 86 ring and the radially projecting shoulder 93 of the stator segment. Thus, each gland segment can have its respective stator, seal ring and pushing ring segments mounted thereon at the factory so as to provide a unitized subassembly, thereby facilitating shipping, handling and subsequent assembly of these stator subassemblies to the shaft.

To permit the two stator subassemblies to be fixedly secured to one another for assembly around the shaft 12, the flat end surfaces 118 of each gland segment each have a pair of openings 119 formed inwardly therefrom, with the openings 119 and gland surface end surface being aligned with the corresponding openings in the opposed glands segment and surface. Most conveniently, the openings 119 in one gland segment are smooth bores, and the openings 119 in the other gland segments are threaded so that threaded fasteners formed as cap screws 120 can be slideably inserted through the two openings at opposite ends of one gland segment and threadably engaged with the threaded openings formed in opposite ends of the opposed gland segments so as to fixedly clamp the two gland segments together and thus form a rigid annular structure.

The opposed gland segments are also preferably provided with alignment pins 122 cooperating with aligned openings 121 associated with opposed ends of the gland segments. These pins are similar to the alignment pins associated with the collar segments in that one end of each pin preferably fixedly secured to its respective gland segment, as by a press fit, and projects outwardly from the end surface so as to be inserted into an opening which opens inwardly from the opposed end surface of the other gland segment. A single such alignment pin provided for cooperation between each opposed pair of end surfaces greatly facilitates the alignment of the two stator subassemblies so that they can be slideably moved together for fixed securement by the cap screws 120 while insuring that proper concentric alignment between the semicylindrical segments is achieved.

One of the opposed end surfaces 118 at each end of the two gland segments is also preferably provided with a flat thin gasket 123 associated therewith and extending along the end surface adjacent the inner annular wall thereof, substantially as illustrated in Figure 2, to thus create an effective seal between the opposed gland member segments when they are clamped together, and thereby peripherally sealingly enclosing the annular chamber 124 which surrounds the seal rings.

Further, the inner end wall of the gland is adapted to substantially abutting contact the end face of the housing part, and an annular flat gasket 125 is typically provided at the interface between these walls to create a seal. To improve on the performance of this gasket and to prevent pressure blowout or extrusion thereof, the end wall of the gland where it engages the gasket 125 is preferably provided with shallow notches or grooves therein, such as by creating a shallow spiral groove or a plurality of shallow grooves of different diameter. Thus, the compression of the gasket 125 between the opposed walls on the housing and gland thus cause the

gasket material to deform or flow into the grooves to create a mechanical lock, and thus provide increased resistance against pressure blowout of the gasket.

To secure the stator assembly to the housing, the gland has a plurality of openings or slots extending axially therethrough, and conventional fasteners such as cap screws 126 extend through the openings and engage within threaded openings (not shown) formed in the end face of the housing.

To facilitate positioning of the rotor assembly on the shaft at the job site, each preassembled rotor subassembly 21A and 21B has a positioning clip assembly 131 (Figures 10 and 11) provided thereon which includes a generally T-shaped clip member 132 provided with a base leg 133 which overlies the outer annular wall of the front sleeve part 35 of the collar segment. This base leg joins to an inner leg 134 which projects radially inwardly so as to overlap and effectively abut against the axial end face 137 defined between the front and rear sleeve parts of the collar segment. A further leg 135 projects outwardly from the base leg 133 in generally perpendicular relationship therewith, and the inner and outer legs 134-135 have a common end face 138 which extends generally perpendicular to the axis of the rotor assembly and which, during assembly of the rotor assembly on the shaft, is disposed so as to abuttingly engage the end face of the stuffing box housing 14 to permit proper positioning of the rotor assembly relative to the stuffing box housing.

Each rotor segment is preferably provided with at least one such positioning clip 131 thereon, preferably substantially at the middle of the semi-cylindrical configuration of the subassembly. The clip member 132 is secured to the collar segment by means of a plastic fastener 136, the shank of which projects through an opening in the base leg 133 into a blind bore 139 which opens radially inwardly from the outer annular wall of

the front sleeve part of the collar. The shank of the fastener has deformable flanges thereon for gripping the bore, such fastener being conventional and similar to the type which is often referred to as a Christmas tree fastener.

The job-site assembly of the split mechanical seal assembly 20 onto the shaft 12 of a fluid handling device 10 will now be briefly described.

The cap screws 69 of rotor assembly 21 are removed to permit separation of the rotor subassemblies 21A and 21B. These subassemblies are then positioned on diametrically opposite sides of the shaft 12 so that the pair of alignment pins which are effectively disposed on diametrically opposite sides of the shaft are aligned with the opposed smooth bores formed in the ends of the opposed collar segment, with the pins and bores being interfitted and the opposed rotor segments being slideably moved toward one another until the end faces abut. The engagement of the inner diameter of the collar member on the shaft, and specifically the engagement of the elastomeric seal ring 34 carried thereby, insures that the rotor assembly is properly centered on the shaft. The caps screws 69 are again reinserted through the smooth bores 67 and engaged with the opposed threaded bores 68 so as to tighten the opposed rotor segments together to insure a tight fitting engagement between the opposed ends of the collar and rotor segments, respectively. After the cap screws 69 have been tightened, the final positioning of the rotor assembly relative to the shaft and housing is carried out. In this respect, the rotor is positioned on the shaft such that the end faces 138 of the positioning clips 131 are disposed in abutting engagement with the end face of the stuffing box housing. The set screws 72 are then tightened downwardly against the shaft to insure that the diametrically opposed side of the rotor assembly is drawn into snug engagement with the shaft. If the other pair

of set [redacted]ews 74 is provided, then th[redacted]re also tightened into snug engagement with the shaft. After all of the set screws have been tightened, the installer then removes the positioning clips 131. This can be accomplished by slipping the flat blade of a screwdriver under the base leg 133 and prying upwardly, which typically effects removal of the plastic fastener 136 so that the entire clip can be readily removed and disposed of.

The stator assembly 22 is now ready to be mounted on the shaft. To do so, the cap screws 120 are removed to effect separation of the semi-cylindrical gland segments, which are then positioned on diametrically opposite sides and are disposed so that the alignment pins 122, which diametrically straddle the shaft, are aligned with the opposed bores and the gland subassemblies are slideably engaged on the alignment pins and slideably moved into a position whereby the opposed end surfaces 118 of the gland segments substantially abut. In this latter position the cap screws 120 are inserted into the appropriate openings so as to threadably connect the gland segments effect a proper tight fit there-between, whereby the gaskets 123 positioned between the end surfaces create a seal between the gland segments. The stator assembly as secured together in position around the shaft is then moved axially toward the rotor assembly so that the seal face 28 on the stator abuts the opposed seal face 27 on the rotor and causes the stator 26 to move axially outwardly (rearwardly) relative to the gland so as to effect outward movement of the pusher ring and partial compression of the springs. The gland is moved forwardly toward the rotor until the end face of the gland, and specifically the annular gasket 125 position thereon, abuts the end face of the stuffing box housing. When so disposed, then the securing cap screws are inserted axially through the appropriate gland openings

and thre[redacted]d into the stuffing box hou[redacted]g so as to effect a secure fixed connection of the gland thereto.

To assist in positioning of the gland assembly on the shaft, each gland segment is preferably provided with two or more plastic centering tabs (not shown) mounted on the outer end face thereof and projecting radially inwardly to a location corresponding to the shaft diameter so as to concentrically position the stator assembly relative to the shaft, which centering tabs are removed after the stator assembly has been firmly attached to the housing. The use of such centering tabs on a gland is conventional.

Summarizing, the seal assembly utilizes a pair of drive pins cooperating with both the stator and rotor face rings, with at least one said drive pin being disposed for cooperation with each rotor and stator face ring segment. These drive pins not only prevent the face rings from rotating or spinning relative to the respective collar and gland during operation, but they also radially retain the face ring segments relative to the respective collar and gland segments during shipping and installation. In addition, each of the face rings segments has a step or shoulder which effectively catches against the respective O-ring segment, which O-rings 51 and 86 are preferably square or rectangular in cross-section so as to perform this function. This latter relationship thus retains the respective face ring in the axial direction relative to its supporting collar or gland, while at the same time the respective drive pin is positioned to retain the face ring in the radial direction. The combination of the drive pin and the rectangular O-ring and their cooperation between each face segment and the respective collar or gland segment thus effectively retains the two halves (i.e., subassemblies) of each of the rotor and stator assembly as a preassembled unit to facilitate handling and installation thereof, and thereby eliminating the need to

separate handle and separately insta the individual parts, particularly the face ring parts or segments. Since handling of the face ring parts or segments greatly increases the risk of physical damage and/or contamination from dirt, these disadvantages are hence effectively eliminated or greatly minimized.

In addition, the improved assembly also has the spring pusher or retainer captured in a manner similar to that used for capturing the seal faces. That is, the spring retainer or pusher is also diametrically split but has an annular shoulder on the outside diameter thereof which is accommodated in a surrounding annular groove defined by the gland shroud, which arrangement thus prevents the spring retainer or pusher member from sliding axially out of the gland. Further, the pins associated with the spring retainer pass through axial holes in the gland shroud, and this prevents the spring retainer from falling out of the gland in the radial direction during handling and installation. This arrangement thus eliminates the need for retaining clips, shoulder screws or buttons which are typically used to capture the spring retainer. This arrangement also insures that the spring retainer halves are located in the same axial plane when the gland halves are assembled so as to insure that the stator face ring halves, which are preassembled in the gland, are properly aligned when the gland halves are assembled around the shaft.

It will be appreciated that in most fluid handling devices the mechanical seal assembly is mounted on a shaft sleeve which surrounds and is nonrotatably secured to the shaft. Any reference herein to the shaft 12 is intended to encompass a situation where the shaft may be provided with a separate sleeve member nonrotatably secured in surrounding relationship thereto, with the mechanical seal assembly being mounted directly on the shaft sleeve.

Dur[redacted] operation, the pressurized [redacted]mping fluid is present in the stuffing box 15 and hence is also present within the annular chamber 124 defined by the gland, which chamber 124 surrounds the major components of the seal assembly, namely the collar, the stator and the rotor. The pressurized fluid is prevented from escaping to the surrounding environment due to the elastomeric seal rings 34, 51 and 86, and due to the mechanical face seal provided between the relatively rotating but snuggly engaged flat seal surfaces 27 and 28. The pressurized pumping fluid thus surrounds the outer periphery or outer diameter of the engaged seal faces 27-28, whereas the lower pressure atmosphere exists adjacent the inner diameter of the engaged seal faces 27-28. The cooperation of the seal faces and the sealing function which they provide is generally conventional and well understood.

Further, in the improved seal assembly of the present invention, the pressurized pump fluid in the chamber 124 acts on the rear surface of the rotor radially outwardly from the diameter of the annular surface 46. The pressure fluid also acts on rear surface of the stator radially outwardly from the diameter from the annular surface 92. The intermediate surface 92, however, has a larger diameter than the intermediate annular surface 46 of the rotor. The pressure fluid in the chamber 124 thus exerts a greater pressure force on the rotor urging it axially outwardly (rightwardly in Figure 2) than the fluid pressure force which acts on the stator urging it axially inwardly (leftwardly in Figure 2), although the difference in these forces is never large enough to overcome the leftward urging of the spring force created by the pressure device. However, even as the pressure level of the working fluid in the chamber 124 increases, and hence creates a larger outwardly (i.e. rightwardly) oriented unbalanced pressure force on the rotor, this force is still overcome by the

spring force, but nevertheless tends to decrease or minimize the contact force between the abutting contact surfaces 39 and 44. However, since the contact pressure between the surfaces 39 and 44 is reduced during operation due to the unbalanced hydraulic pressure force imposed on the rotor, this thus minimizes any undesirably effects which result from irregularities with respect to the flatness of the contact surface 39, and thus minimizes any undesired twisting or distortion of the rotor since the contact stresses at the contacting faces 39 and 44 are not only minimized but progressively reduced as the working pressure of the fluid increases, and thus this seating relationship at surfaces 39-44 becomes less critical to the overall performance of the seal.

It will be recognized that variations of the disclosed apparatus, including rearrangement of parts, lie within the scope of the present invitation.

Claims

1. A mechanical seal assembly for creating a sealed engagement between an annular stuffing box housing and a shaft which projects concentrically out of the stuffing box housing and is rotatable about its longitudinal axis, said mechanical seal assembly comprising:

a rotor assembly which includes an annular collar which is mountable in sealed and nonrotatable engagement with the shaft in concentric surrounding relationship therewith, a first annular face ring which is sealingly and concentrically mounted within said collar and has an axially exposed end which defines thereon an axially facing first annular seal face, and a first annular elastomeric seal ring disposed between and sealingly engaged with annular walls on said collar and said face ring;

an annular stator assembly nonrotatably mountable on the stuffing box housing in generally concentric and surrounding relationship to the shaft and including an annular gland member which sealingly engages and nonrotatably mounts to the stuffing box housing, a second annular face ring which is mounted generally concentrically within said gland member, said second face ring defining a second generally flat annular seal face on an inner axial end thereof so that said second seal face is disposed in axially opposed relation to said first annular seal face, and a second elastomeric seal ring disposed between and sealingly engaged with annular surfaces on said gland member and said second face ring;

said rotor assembly being split axially along a substantially diametral plane into two substantially semi-cylindrical rotor subassemblies with said split as it extends along said diametral plane splitting each of said collar, said first elastomeric seal ring and said first face ring into substantially semicircular segments;

each said rotor subassembly having adjacent and opposed stop surfaces defined on the segments of said collar and said first face ring to both axially and radially restrain said first face ring segment relative to the respective collar segment to prevent separation therebetweeen, whereby the respective segments of the collar, first face ring and first elastomeric seal ring of each rotor subassembly are preassembled to define a unitized subassembly prior to mounting thereof on the shaft.

2. A seal assembly according to Claim 1, wherein:

said stator assembly being axially split along a substantially diametral plane into two substantially semi-cylindrical stator subassemblies with said split along said diametrical plane splitting each of the gland member, said second face ring and said second elastomeric seal ring into substantially semicircular segments;

each said stator subassembly having adjacent and opposed stop surfaces cooperating between said gland member and said second face ring segments to both axially and radially restrain said second face ring segment relative to said respective gland member segment to prevent separation therebetween, whereby the respective segments of the gland member, second face ring and second elastomeric seal ring of each stator subassembly can be preassembled to define a unitized subassembly prior to mounting thereof on the shaft.

3. A seal assembly according to Claim 1 or Claim 2, including two threaded fasteners which cooperate with openings formed in opposed ends of the collar segments on diametrically opposite sides of the shaft for fixedly securing the collar segments together in an annular configuration in surrounding relationship to the shaft, said two threaded fasteners being disposed within a securing plane which extends generally perpendicularly

with respect to the axis of the shaft, and a pair of set screws threadably supported on the collar for engaging the shaft to fix the collar to the shaft, each collar segment having a said threaded opening extending radially therethrough and having one of said set screws threadably engaged therein, said set screws being disposed substantially within said securing plane.

4. A mechanical seal assembly according to Claim 3, wherein said pair of set screws are disposed adjacent one diametral side of the collar so that the set screws are disposed closely adjacent and on circumferentially opposite side of one of said fasteners so that the reaction force from the set screws onto the collar has minimal effect with respect to its tendency to separate the collar segments.

5. A seal assembly according to any one of Claims 1-4, wherein a pushing device is associated with and nonrotatably coupled to said gland member and includes an annular pusher ring which has an end face normally maintained in pushing abutting contact with an outer axial end face of said second face ring, and a plurality of springs cooperating between said gland member and said pusher ring and urging said second face ring axially toward said first face ring, said pusher device including said pusher ring being axially split along said diametral plane into substantially semicircular segments with each said segment being retained by the respective stator subassembly.

6. A seal assembly substantially as hereinbefore described with reference to any of figures 1 to 11.

Application No:	GB 0110906.5	**Examiner:**	Kevin Hewitt
Claims searched:	1-6	**Date of search:**	31 August 2001

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): F2B

Int Cl (Ed.7): F16J 15/34; F04D 29/10, 29/12

Other: Online WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 2281763 A	(BESSETTE et al.) See especially Figs 1 and 2	-
X	WO 97/04256 A1	(BW/IP INTERNATIONAL) See especially Figs 1 and 12 and claim 1.	1, 2, 5
X	US 5961122 A	(MARSI) See especially Figs 1 and 12 and claims 3 and 4.	1, 2, 5

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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